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(54) Submarine electric cable

(57) In laying a submarine electric cable C on the bed F of a body of water, the bed having even and uneven tracts TL, TA to be crossed by the cable when laid, stiffening tubes ET_1, ET_2... are applied around the cable, over the portion which is destined to cross the uneven tract, as that portion passes from the cable laying ship's capstan V to the water surface A, the tubes improving the resistance to bending of the cable over the portion concerned. Damage to the cable, from being suspended between high points of the bed, is thus prevented.

Corrugated half-tubes are held together by clamps M1 and collars C1, C3 (Figure 3 and 4 not shown), the collars having openings to allow entry of water.

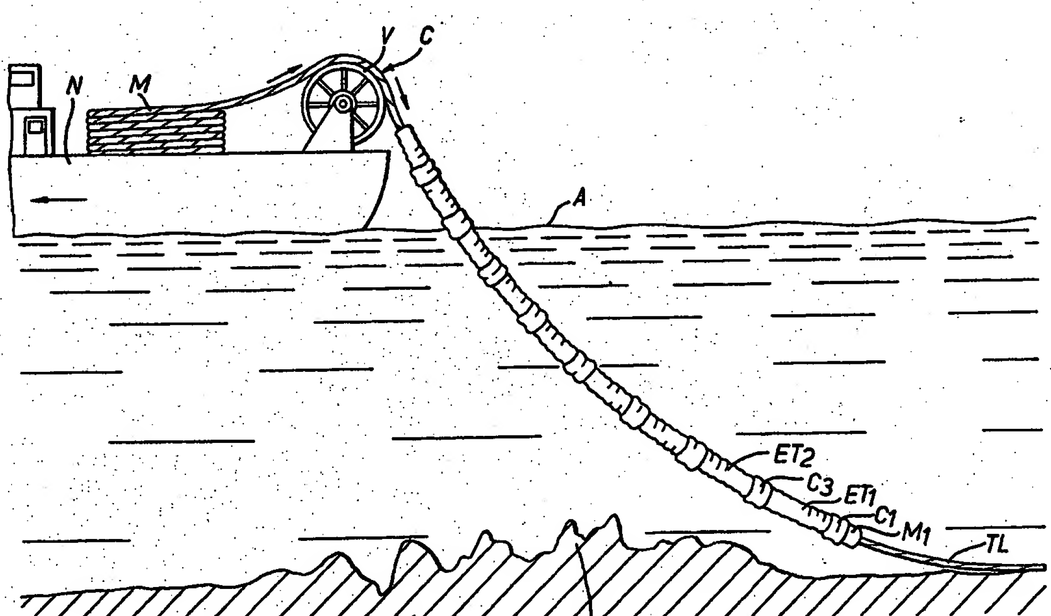

FIG.5.

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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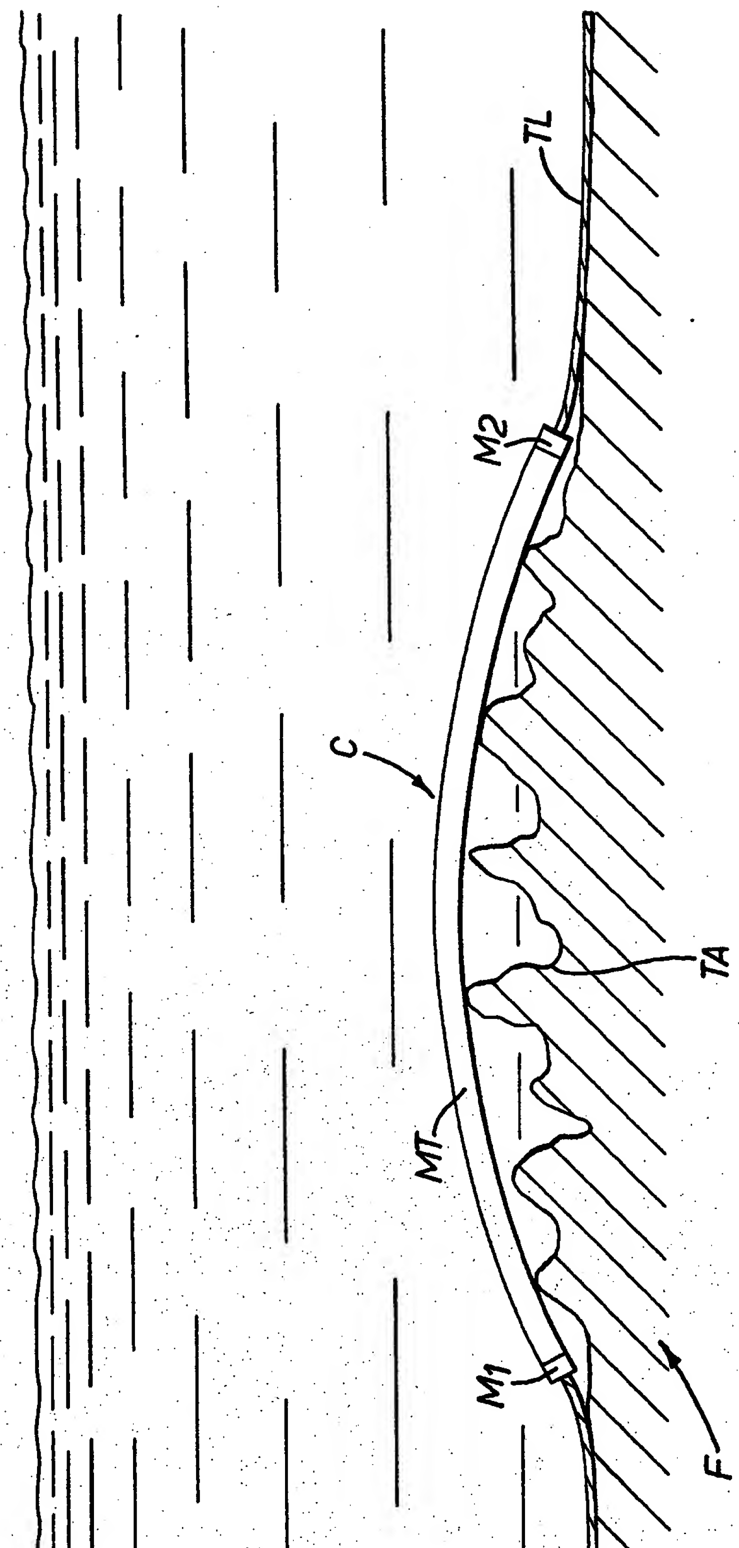

FIG. 1.

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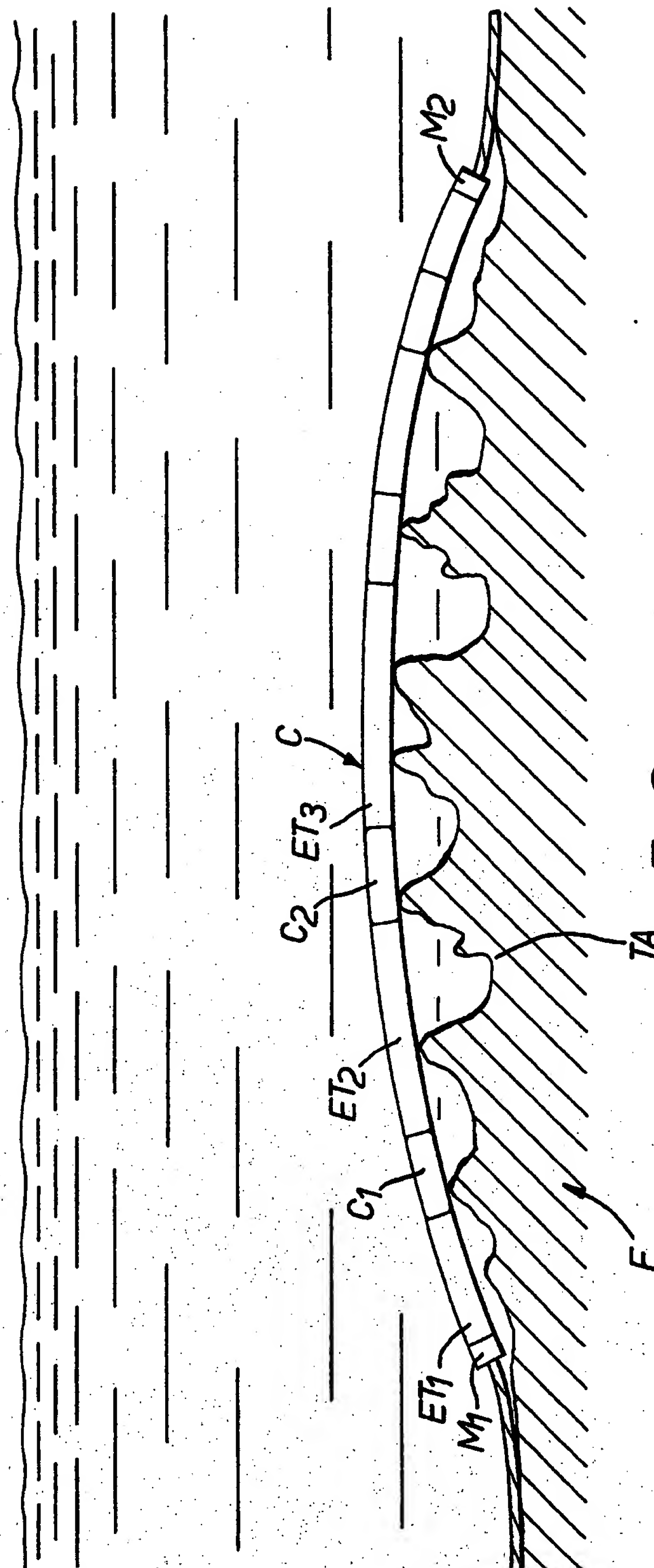

FIG.2.

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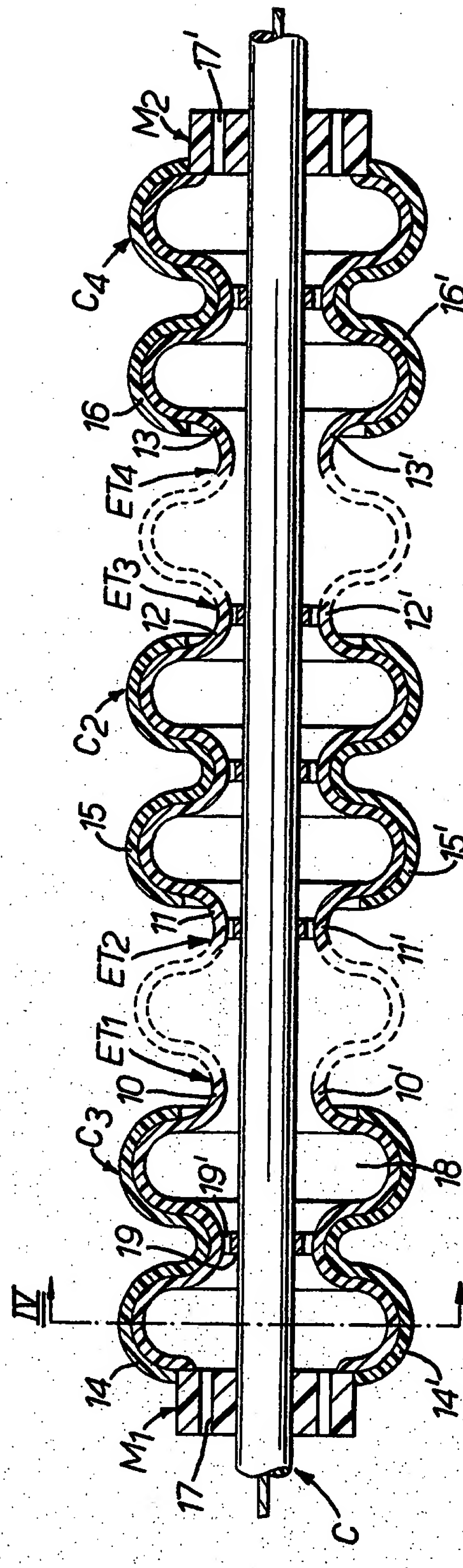

FIG. 3.

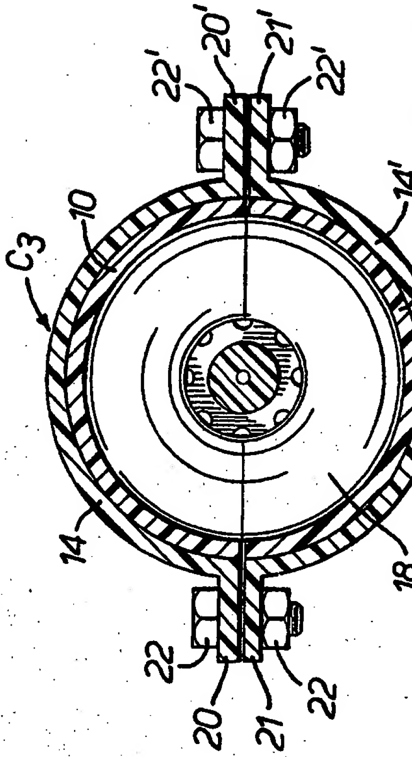

FIG. 4.

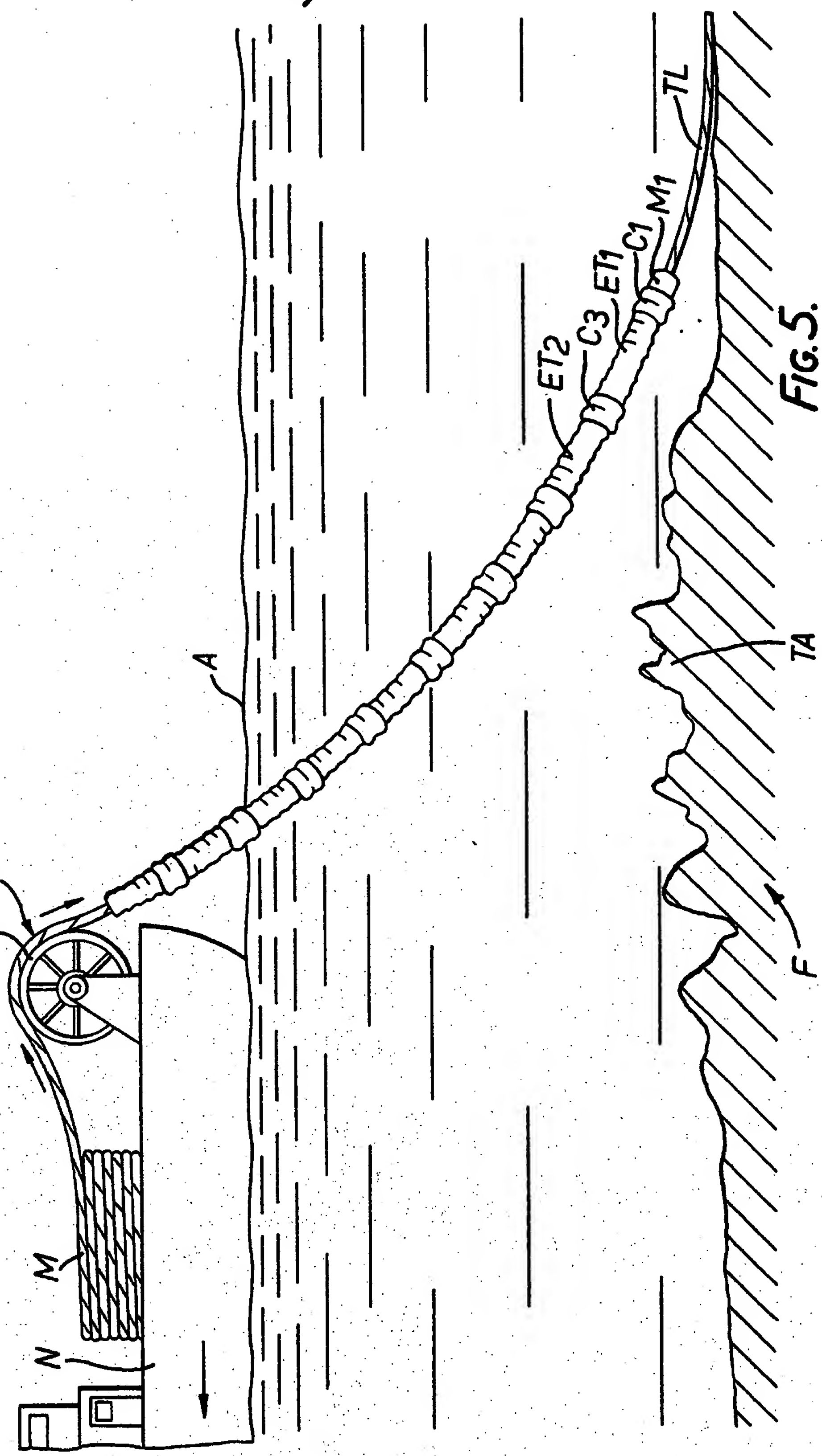

FIG. 5.

SPECIFICATION

Submarine electric cable

The present invention relates to a submarine electric cable laid on the bed of a body of water, and to a method of laying such a cable.

One cause of problems when laying a submarine electric cable is an uneveness of the bed on which the cable is being laid: spurlike projections, dips and hollows etc. may be encountered. A result of an uneven bed is that the cable itself becomes suspended between high points, subjecting the cable to bending forces. These forces may be dangerous in that they may bend the cable to a smaller radius than its minimum permitted bending radius so as to cause damage and irreversible deformation of the cable with detriment to the mechanical and electrical properties of the cable. Thus the protective sheath of the cable may be distorted or the insulation of the cable may be mechanically impaired. For example, the minimum permitted bending radius is about 3 m for submarine cables of large diameter (say an outer diameter of 150 mm), and about 1.5 m for submarine cables of small diameter (say an outer diameter of 60 mm). The problem is made worse where the laid cable is subjected to water currents because this increases the strains to which the suspended lengths of the cable are exposed.

In order to eliminate these risks, the protective sheath of the cable could be reinforced and stiffened for example, in accordance with techniques generally in use for submarine cables, by means of an armouring comprising at least one layer of elongate metal elements. However, armouring which sufficiently stiffens the cable for it to withstand all the stresses to which it may be subjected when laid upon uneven terrain, removes from the cable the flexibility which is necessary for winding the cable around a bobbin or in coils. It would then not be possible to carryout the cable laying operation. Moreover, if such armouring were applied over the full length of the cable, it would represent a wasteful expense for the frequent cases where only a few uneven tracts are to be found in the bed on which the cable is to be laid.

Another solution might be to install fixed supports on the bed, upon which the cable can be laid. Thus, flexible containers could be positioned where required on the bed and injected with a cement which then sets. This technique is widely used in submarine pipelaying, but is not so feasible in the case of electric cables, owing to the flexibility of the cable and the consequent requirement for a considerable number of the supports: also these supports would not adequately guarantee the cable against eventual displacement caused by underwater currents.

A different solution might be to level the bed on which the cable is to be laid, at least demolishing the more dangerous obstructions. However, this is neither simple nor economical to carry out especially when it involves eliminating a widespread surface uneveness of small vertical dimensions.

In accordance with the present invention, there is provided a submarine electric cable comprising at least one insulated and screened conductor and a protective sheath, the cable being laid on the bed of a body of water and crossing both even an uneven tracts of the bed, stiffening tubes being disposed around the cable over the uneven tracts and having a greater resistance to bending than the cable alone.

Preferably, the stiffening tubes comprise a material having a specific gravity sufficiently approximating to that of the water.

Also in accordance with the present invention, there is provided a method of laying a submarine electric cable on the bed of a body of water, the cable having at least one insulated and screened conductor and a protective sheath and the bed having both even and uneven tracts to be crossed by the cable when laid, the method comprising applying a stiffening tube or tubes around the cable, over a portion thereof destined to lie across an uneven tract, as that portion of the cable passes to the surface of the water from a cable laying capstan on a ship from which the cable is laid, the tube or tubes serving to improve the resistance to bending of the cable over that portion.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic illustration of a length of submarine electric cable laid on the bed of a body of water and provided with a stiffening tube in accordance with the invention;

Figure 2 is a similar illustration of a length of submarine electric cable provided with a series of stiffening tubes;

Figure 3 is a longitudinal section through a preferred series of stiffening tubes;

Figure 4 is a cross-section through a preferred embodiment of stiffening tube; and

Figure 5 is a schematic illustration of a submarine cable being laid by a method in accordance with the present invention.

Figure 1 shows a length of submarine electric cable C laid on the bed F of a body of water, and shows a relatively uneven tract TA and a relatively even tract TL of the bed. The cable C comprises at least one insulated and screened conductor and a protective sheath, which may comprise an armouring formed of elongate metal elements. Over the uneven tract, a stiffening tube MT is disposed around the cable, with first and second clamps M_1 and M_2 being clamped onto the armouring of the cable at the opposite ends of the tube MT and having outer diameters at least equal to the outer diameter of the tube to prevent the latter from sliding along the cable. The stiffening tube improves the resistance to bending of the cable and in the example shown has itself a greater resistance to bending than the cable alone. For a given applied bending force, the stiffening tube would bend less than the cable, so that in the arrangement shown the stiffening tube presents a bending radius greater than the minimum permitted bending radius of the cable itself. In this manner, the components of the submarine cable (conductor, screen, insulation, protective sheath) are not subjected to flexions beyond safety limits.

It has moreover been found experimentally that

the best results are obtained when the specific gravity of the material of the stiffening tubes sufficiently approximates to that of the water. Therefore plastics materials are preferred, for example polyester reinforced with fibreglass to provide good mechanical properties, with a substantial loading of the glass fibres to result in a specific gravity of about 1.5. The only metal tolerated to-date is aluminium, of a specific gravity of 2.8, provided with a corrosion protective layer of bitumen or like substance of a specific gravity less than 1.00.

Preferably the stiffening tube has a greater inner diameter than the outer diameter of the cable and the latter is supported coaxially of the stiffening tube by means of centering elements. The interspace between the cable and the stiffening tube is occupied by water from the surrounding body of water. The water is able to flow into and out of the interspace through openings provided for example in the clamps M_1 and M_2 and promotes a rapid and effective dissipation of the heat generated in the cable when in service.

In cases where the uneven tract being crossed is quite long (Figure 2), it is preferable for a series of stiffening tubes ET_1, ET_2, ET_3, etc. to be arranged one-after-another and connected to each other by appropriate connecting means, e.g. connecting means C_1 between tubes ET_1 and ET_2, and connecting means C_2 between tubes ET_2 and ET_3. The connecting means are preferably collars which embrace the ends of the two adjacent tubes. Each of the tubes has a greater resistance to bending than the cable, and the series of tubes may include an intermediate tube or plurality of tubes of a given, relatively high resistance to bending and tubes towards the ends of the series having a lower resistance to bending (or successive tubes towards the ends having progressively lower resistance to bending): this assists the cable to adopt an optimum profile in the transition zones between the uneven tract and even tracts and continuity with the unstiffened lengths of cable.

Figure 3 shows a series of stiffening tubes ET_1, ET_2, ET_3, ET_4 disposed between first and second clamps M_1 and M_2. Each tube is formed with annular corrugations and is divided into first and second shells 10, 10'; 11, 11'; 12, 12'; 13, 13' of C-shaped or semicircular cross-section. The two shells of each tube are held together by collars such as C_2, C_3, C_4. Each collar is divided into first and a second halves (14, 14'; 15, 15'; 16, 16') of C-shaped or semicircular cross-section, and each collar is formed with annular corrugations: connecting means are provided for securing the two halves of each collar together (not shown in Figure 3). The corrugations of the collar and the corrugations of the stiffening tubes are correspondingly profiled so that the collars fit over the tubes as shown. The collars C_3 and C_4 just serve to hold together the shells 14, 14' and 16, 16' of the respective tubes ET_1 and ET_4. The collar C_2 serves to hold shells 11, 11' together, to hold shells 12, 12' together, and also serves to connect together the two adjacent tubes ET_2 and ET_3 which are formed by the shells 11, 11' and 12, 12' respectively. For this, it is necessary for the corrugations of the collar halves 15 and 15' of collar C_2 to be engaged simultaneously with the end corrugations of shells 11, 11' and 12, 12' of the tubes ET_2 and ET_3.

The clamps M_1 and M_2 may comprise devices known *per se* in the electric cables art, but they have an outer diameter at least equal to the outer diameter of the stiffening tubes so as to prevent the latter from sliding along the cable. Figure 3 shows the interspace 18 between the cable and the stiffening tubes and this is occupied with water from the surrounding body of water, flowing in and out through openings 17, 17' in the clamps M_1, M_2.

The cable is supported coaxially of the stiffening tubes by centering elements 19 which can simply comprise, as shown, protuberances on the inner surface of the shells forming the stiffening tubes. These centering elements must be provided in sufficient number such as to support the cable in its position coaxial of the stiffening tubes throughout the series of tubes, and are provided with openings 19' to permit the flow of the water along the interspace 18.

The use of tubes provided with corrugations (particularly but not necessarily annular) leads to certain practical advantages. Firstly, the tube exhibits good mechanical resistance both to bending and pressure, and this is necessary for supporting the lengths of suspended cable. Secondly, it enables the end-to-end connection of adjacent tubes to be carried out in an extremely simple and rapid manner.

The stiffening tubes and the collars may be formed of various materials. A preferred material both for the tubes and the collars is, as mentioned above, polyester reinforced with fibreglass and having a specific gravity of the order of 1.5. The stiffness of each tube may be changed as required by selecting the composition of the material, the thicokness of the tube and the profile of the corrugations, and the weight may be limited in order to facilitate the laying operation as will be described.

For further increasing the stiffness of the series of tubes, one or more further series of tubes may be superimposed over the first series, to form a multi-layer arrangement, the tubes in the further series being divided into shells in like manner to the first series. Preferably, the shells of adjacent layers are staggered in the direction longitudinally of the cable and are relatively rotated through 90°.

Figure 4 is a cross-section on the line IV-IV in Figure 3 and shows a preferred embodiment of the collar C_3. The collar comprises two halves 14 and 14' of C-shaped or semicircular cross-section and having radial flanges 20, 20' and 21, 21' along their edges. These flanges are provided with aligned holes for use in securing the two halves of the collar together, for example by nuts and bolts 22 and 22' as shown.

Figure 5 schematically illustrates the laying of a submarine electric cable and providing it with stiffening tubes in accordance with the present invention. The cable C is shown being laid on the bed F of a body of water, the bed having an even tract TL and an uneven tract TA. The cable C is paid-off from a coil M on the deck of a ship N, passing over a cable

capstan V and descends under gravity to lie on the bed F. The cable C is provided with the stiffening tubes over a portion of its length destined to lie upon the uneven stretch TA of bed F, the stiffening tubes being applied to the cable as the portion of cable in question passes from the cable capstan V to the water surface A.

It is a particularly simple and rapid operation to apply stiffening tubes as shown in Figures 3 and 4. Firstly, clamp M_1 is applied to embrace the protective sheath of the cable. Then, abutting clamp M_1, first and second shells are disposed around the cable and coupled together to form the tube ET_1, collar C_1 being applied around tube ET_1 at its end in contact with clamp M_1. At the opposite end of tube ET_1, two further shells are disposed around the cable to form tube ET_2. The collar C3 is applied so as to embrace the adjacent ends of the two tubes ET_1 and ET_2. In like manner, a plurality of stiffening tubes and collar are applied to stiffen the cable over the desired length. Finally, a collar (not shown in Figure 5) is applied around the free end of the clamp last stiffening tube of the series, and a second clamp (not shown in Figure 5) is applied to embrace the protective sheath of the cable.

CLAIMS

1. A submarine electric cable comprising at least one insulated and screened conductor and a protective sheath, the cable being laid on the bed of a body of water and crossing both even and uneven tracts of the bed, stiffening tubes being disposed around the cable over the uneven tracts and having a greater resistance to bending than the cable alone.

2. A submarine electric cable according to claim 1, in which the stiffening tubes comprise a material of specific gravity sufficiently approximating to that of the water.

3. A submarine electric cable according to claim 2, in which the specific gravity of the material of the stiffening tubes is equal to or less than 2.8.

4. A submarine electric cable according to claim 3, in which the specific gravity of said material is about 1.5 or less.

5. A submarine electric cable according to any preceding claim, in which said stiffening tubes have an inner diameter greater than the outer diameter of said cable, the cable being supported coaxially within the stiffening tubes by centering elements with the interpsace between the cable and the stiffening tubes being occupied by water from the surrounding said body of water.

6. A submarine electric cable according to any preceding claim, in which the stiffening tubes are disposed, at the respective uneven tracts, between first and second clamps which embrace the protective sheath of the cable, said clamps having outer diameters at least equal to the outer diameter of said stiffening tubes.

7. A submarine electric cable according to any preceding claim, comprising a series of said stiffening tubes arranged one-after-another at each said uneven tract.

8. A submarine electric cable according to claim 7, in which stiffening tubes towards the ends of each said series exhibit less resistance to bending than at least one intermediate tube in said series.

9. A submarine electric cable according to claim 8, in which said stiffening tubes are formed with annular corrugations.

10. A submarine electric cable according to claim 7 or 8, in which each said tube is divided into first and second shells of C-shaped cross-sections with fastening means connecting the first and second shells together and connecting adjacent tubes together, the shells being provided on their inner surfaces with protuberances serving to support the cable coaxial relative to the tubes.

11. A submarine electric cable according to claim 10, in which each said fastening means comprises a collar.

12. A submarine electric cable according to claim 11, in which each collar is formed with annular corrugations.

13. A submarine electric cable according to claim 11 or 12, in which each collar is divided into two halves of C-shaped cross-section and is provided with means for connecting the two halves together.

14. A submarine electric cable according to claim 13, in which said connecting means for connecting the two halves of each collar together comprise projections of the respective halves and means for securing respective projections together.

15. A submarine electric cable according to any one of claims 7 to 14, comprising two or more said series of tubes, superimposed in layers with the shells of adjacent layers being staggered in the direction longitudinally of the cable and rotated through 90°.

16. A submarine electric cable according to any one of claims 7 to 15, in which said tubes and collars comprise polyester reinforced with fibreglass.

17. A method of laying a submarine electric cable on the bed of a body of water, the cable having at least one insulated and screened conductor and a protective sheath and the bed having both even and uneven tracts to be crossed by the cable when laid, the method comprising applying a stiffening tube or tubes around the cable, over a portion thereof destined to lie across an uneven tract, as that portion of the cable passes to the surface of the water from a cable laying capstan on a ship from which the cable is laid, the tube or tubes serving to improve the resistance to bending of the cable over that portion.

18. A method according to claim 14, comprising the steps of applying a first clamp to embrace the protective sheath of the cable; disposing around the cable first and second shells of C-shaped cross-sections to form a first said tube abutting said first clamp; applying a collar around said first tube at its end abutting said first clamp, which collar comprises first and second halves of C-shaped cross-sections and is formed with annular corrugations complementary and interfitting with annular corrugations with which said first tube is formed; applying a second pair of shells around the cable, at the other end of the first tube, to form a second said tube, also having annular corrugations; applying a second to embrace the adjacent ends of the first and second

tubes, the second collar being formed with annular corrugations complementary and interfitting with those of the first and second tubes; similarly applying a plurality of further said tubes and collars around the cable to stiffen the cable over the desired length; applying a further collar around the free end of the last tube; and applying a second clamp around the cable to embrace its protective sheat, each said clamp having outer diameters at least equal to the outer diameters of said stiffening tubes.

19. A submarine electric cable laid on the bed of a body of water and substantially as herein described with reference to Figure 1 or Figures 2-4 of the accompanying drawings.

20. A method of laying a submarine electric cable, said method being as claimed in claim 17 and substantially as herein described with reference to Figure 5 of the accompanying drawings.

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